RESEARCH PAPER 54
DECEMBER 1957

SEEDING-DEPTH TRIALS WITH BITTERBRUSH (PURSHIA TRIDENTATA) IN IDAHO

by

JOSEPH V. BASILE AND RALPH C. HOLMGREN

DIVISION OF RANGE MANAGEMENT RESEARCH

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
OGDEN, UTAH
REED W. BAILEY, DIRECTOR

ACKNOWLEDGEMENT

Tests reported herein were part of a cooperative study conducted by the Intermountain Forest and Range Experiment Station and the Idaho Fish and Game Department through Federal Aid in Wildlife Restoration Project W-111-R. This is a completion report for all seeding-depth studies under Job 4 of that project.

Research Paper 54 December 1957

SEEDING-DEPTH TRIALS WITH BITTERBRUSH (PURSHIA TRIDENTATA) IN IDAHO

By

Joseph V. Basile and Ralph C. Holmgren
Range Conservationists

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U. S. Department of Agriculture
Ogden, Utah
Reed W. Bailey, Director

SEEDING-DEPTH TRIALS WITH BITTERBRUSH

(*PURSHIA TRIDENTATA*) IN IDAHO

Joseph V. Basile and Ralph C. Holmgren
Division of Range Management Research

Bitterbrush (*Purshia tridentata* (Pursh) DC.), a palatable shrub species, shows promise of becoming useful for artificial browse revegetation on depleted big-game winter ranges in southwestern Idaho.

As part of a cooperative interagency browse revegetation research program begun in 1949, several test plantings were made to determine optimum depth for seeding bitterbrush. The game ranges on which the plantings were made are moderately steep, south-facing slopes; the soils are loose, coarse sandy loams derived from underlying granite. Winter snows make up two-thirds of the 22-inch average annual precipitation. Summer rains generally occur as infrequent, highly localized thunder showers of short duration. An annual type vegetation predominates, with cheatgrass (*Bromus tectorum* L.) as the main constituent.

METHODS AND RESULTS

Bitterbrush seed were planted at two or more depths in late fall each year from 1949 through 1955, with the exception of 1953. Because little was known about bitterbrush seeding the early studies were exploratory, and the study design varied from year to year. As information was accumulated and newly gained knowledge was incorporated in each succeeding trial, the designs became more complex. The results from each year's planting are presented below, immediately following the description of method and design for that particular test.

Nonstratified seed were used in all trials. Except for the use of tetramine-treated seed in the 1954 and 1955 trials, no special treatment or protection was given any seed.

Individually Sown Seed

Three Depths

In November 1949, bitterbrush seed from a lot that had shown a viability of 92 percent in the laboratory (excised embryo germination) were planted at three depths: 1/2 inch, 1½ inches, and 2½ inches. One hundred seeds were planted singly by hand in each of two plots for each depth. The seeds were never closer than 3 inches from each other.

Emergence of seedlings occurred in April 1950. Numbers of emerged seedlings were 41 and 32 in plots seeded at 1/2-inch depth, and 14 and 17 in plots seeded at 1½ inches. No seedlings emerged from the 2½-inch seedings. Emergence

was earlier from the lesser depth: over 90 percent of the seedlings that came up from 1/2 inch emerged before April 12, whereas only 58 percent of those from 1½ inches emerged by that date.

During the summer an attempt was made to recover the seeds from spots where seedlings did not emerge. Only 70 seeds were found. Distribution of the recovered seeds and the percentages that apparently had germinated but not emerged were as follows:

	Seeding depth		
Depth	1/2"	1½"	2½"
No. of seeds	27	25	18
Percent germinated	70	84	100

Eight Depths, Two Seed Sizes

In the fall of 1950 the study was repeated using eight planting depths: 0, 1/4, 1/2, 3/4, 1, 1¼, 1½, and 2 inches. Two lots of seed were used, one with large seeds (about 14,500 per pound) and one with small seeds (about 18,500 seeds per pound). Tests by the excised embryo technique indicated viability of these lots to be 89 and 91 percent, respectively. There were two randomized blocks of plots of 50 singly sown seeds for each depth x seedlot combination. The total number of seedlings emerging was about the same for the two seedlots, 123 and 122. Since no significant block or seedlot differences appeared, the results shown in table 1 are data combined from both blocks and both seedlots.

Table 1.--Emergence and mortality of bitterbrush seedlings from 200 seeds at each of 8 planting depths

	Seeding depth (inches)							
	0	1/4	1/2	3/4	1	1¼	1½	2
				Number of seedlings				
Total emergence	2	48	94	59	21	12	9	0
Emergence before March 27	2	46	60	16	2	0	0	-
Alive in midsummer	0	8	52	42	9	4	6	-
				Percent mortality				
Before March 27[1]	100.0	71.7	23.3	0	0	-	-	-
After March 27[2]	-	46.7	35.0	28.8	57.1	66.7	33.3	-

1/ Percent mortality based on seedlings emerged before March 27.

2/ Spring and early summer mortality based on seedlings alive on March 27 or emerging subsequently.

The highest rate of emergence in this trial was from seed placed 1/2 inch below the ground surface. A change of 1/4 inch in either direction from this depth resulted in little more than one-half the number of seedlings produced from the 1/2-inch depth. Greater deviations from the 1/2-inch depth resulted in progressively lower emergence.

As in the previous trial, emergence occurred earlier from seed planted at the lesser depths. Seventy-five percent of the total emergence from depths of 1/2 inch or less occurred before March 27, whereas only 27 percent of the seedlings from 3/4 inch, and 10 percent of those from 1 inch, had emerged by that date. This early emergence from depths of 1/2 inch or less was detrimental, however, in that 45 percent of these seedlings had died before March 27, in contrast with no mortality until that time from seeds planted at depths of 3/4 inch and 1 inch. Many of the seedlings that died before March 27 had been lifted out of the ground by frost heaving; the remainder appeared to have been frozen. None of the mortality that occurred after that date was attributed to frost.

The month of April was dry: there was no precipitation between March 30 and April 28. The cause of seedling losses occurring after March 27, except for a few obviously the result of insect damage, was presumed to be this drought, since most of the mortality occurred during April. Survival through this period was not related to seeding depth.

The wide difference in seedling numbers before March 27 between plots seeded at 1/2 inch and 3/4 inch was materially reduced by midsummer. There was no significant difference in numbers of living seedlings from these two depths on July 9. The original advantage of the lesser depth was lost largely as a result of early-season mortality.

Two Depths, Three Seedbed Conditions

In the fall of 1951, a test was conducted to compare results from seeding depths of 1/2 inch and 1 inch on two sites and with three seedbed conditions. Site 1 is a steep slope (50%) with a residual soil. Site 2, a few rods distant from site 1, is a gently sloping (20%) alluvial fan. Three seedbed conditions were created on plots that were (1) relatively undisturbed, (2) scalped, and (3) scalped and leveled.

Ten replicate blocks of five plots each were selected on each site. Ten seeds were sown individually in a 10-inch circular area in the center of each 2½-foot diameter plot. One plot in each block represented the first seedbed condition, in which the plot was disturbed only to the extent required to open ten narrow holes 1 inch deep, place a seed in each hole, and press their walls together. Two other plots in each block were scalped to provide the second seedbed condition, in which the surface 2-inch layer of soil was removed to destroy the plant cover and remove residual weed seeds, a measure found necessary to minimize competition for soil moisture.[1/] On one of these, seeds were

---

[1/] Holmgren, Ralph C. 1956. Competition between annuals and young bitterbrush (Purshia tridentata) in Idaho. Ecology 37: 370-377.

planted 1 inch deep, and on the other 1/2 inch deep. The remaining two plots in each block were also scalped, and the sloping surface was then made level by excavating the uphill side, pulling the soil out to form a flat shelf about 2½ feet across (third seedbed condition) on which seeds were planted at depths of 1 inch and 1/2 inch. This was done to reduce insolation on the seed spots in late winter and early spring with the intention of delaying the date at which soil temperature favorable for germination would occur. The test was repeated in 1952 on site 1 only, but with both seeding depths on the undisturbed soil as well as on each of the two types of scalped plots.

The average numbers of seedlings that emerged from the variously treated plots in the two years' trials are shown in table 2. In the first year, on both sites and on both forms of scalped seedbed, emergence from the 1/2-inch depth was significantly greater ($P < .01$) than from the 1-inch depth. There were no significant differences ($P > .05$) in number of emerging seedlings as a result of manipulating the slope gradient of the seedbed, however. Unfortunately, it was not possible to get to the plots early enough to determine whether the variation in slope or the difference between sites had any relation to date of emergence, and hence to possible damage by frost.

Table 2.--Average number of seedlings emerging in spring from plots where 10 seeds had been planted the previous fall at 1/2-inch and 1-inch depths

	Undisturbed		Scalped		Scalped and leveled	
	1/2 inch	1 inch	1/2 inch	1 inch	1/2 inch	1 inch
	Average number of seedlings					
	(1952 results from 1951 seeding)					
Site 1	not seeded	1.8	6.8	1.9	6.8	2.8
Site 2	not seeded	6.1	8.4	1.3	9.0	1.2
	(1953 results from 1952 seeding)					
Site 1	5.5	4.7	5.7	3.4	6.9	5.9

On site 1, numbers of seedlings from the 1-inch depth on undisturbed soil were essentially the same as from that same depth on scalped plots. On site 2, on the other hand, there were significantly more ($P < .05$) seedlings from 1 inch on undisturbed plots than from the same depth on either of the two scalped plots. The significant site x seedbed condition interaction might be explained by the difference in texture of the surface inch of soil on the two sites. The soil of site 1 forms a firmer crust than the soil of site 2 as it dries out. The soil of site 2 is similar except that it contains an abundance of very coarse sand particles in the surface inch or so. Presumably the relatively high rate of emergence from undisturbed soil on site 2 reflects the ease

with which seedlings could pierce this coarse-textured soil. Removal of this coarse-textured layer by scalping exposed a soil similar to that on site 1, and resulted in greater crusting and less emergence.

On site 1 in the second year, seedling emergence was again greater from 1/2 inch than from 1 inch. The differences were not as marked, however, as they had been the first year; the only significant difference ($P < .05$) between depths appeared on the seedbeds scalped but not leveled.

Seed Spots with Varying Numbers of Seed

Emergence from singly planted seeds apparently is greatest from the 1/2-inch depth, but in some years frost heaving may cause considerable mortality among seedlings from this depth. Since no loss from frost heaving was observed from plantings at greater depths, it appeared possible to minimize this mortality factor by sowing deeper than 1/2 inch and still insure high emergence by sowing seeds in small groups rather than singly. To explore this possibility, the following study was conducted.

In November 1954, eight blocks of scalped plots were seeded on each of two sites comparable except for exposure: site 1 faces south and site 2 faces west. Each block contained 48 seed spots, arranged in six rows of 8 each. To each row was assigned at random one of six planting depths ranging at 1/2-inch intervals from 1/4 inch to 2-3/4 inches. Each seed spot within a row represented a different seed-group size, also assigned at random. Seed groups contained 1, 2, 4, 6, 8, 12, 16, or 24 seeds.

This study was repeated the following year on the south slope only, with essentially the same results.

Frost Heaving

Seeds from 41 percent and 23 percent of the spots seeded at the 1/4-inch depth on the south- and west-facing slopes, respectively, were found heaved out of the soil by frost action before or at about the time germination started. For this reason, results from the 1/4-inch depth are omitted from most of the following discussion. Seeds from other depths were not heaved, nor were seedlings from any depth.

Pattern of Emergence

Emergence was first noted on March 30, 1955, and plots were examined every 3 to 5 days thereafter during the period of seedling emergence. Initial emergence tended to be early at lesser depths and larger group sizes, and progressively later at greater depths and smaller group sizes (table 3).

Table 3.--Days after March 29, 1955, when emergence was first noted from seed planted the previous fall in groups of 1 to 24, at five depths, on south and west exposures

Number of seeds in spot	Seeding depths (inches) and exposures									
	3/4		1-1/4		1-3/4		2-1/4		2-3/4	
	S	W	S	W	S	W	S	W	S	W
	Number of days[1]									
1	9	13	27	27	-	49	-	-	-	-
2	6	18	13	18	27	-	-	-	-	-
4	6	13	9	13	18	23	23	-	-	-
6	6	13	9	13	13	18	23	-	-	-
8	6	9	9	13	13	23	18	-	-	-
12	1	6	6	13	13	13	13	49	30	-
16	1	6	1	9	13	18	23	27	35	-
24	1	6	6	9	9	13	13	27	18	-

[1] For example, 1 represents March 30; 13, April 11; 27, April 25; 49, May 17.

Each half-inch increment in seeding depth resulted in a delay in date of initial emergence. These delays increase with increasing depth, and probably include the time required for the soil to become warm enough for germination plus the time required for hypocotyl growth through increasing distances. In practically every case initial emergence was later on the west than on the south slope, probably because the daily duration of direct sunlight was shorter on the west.

The more seeds per spot, the more quickly initial emergence was observed. It is notable that the smaller seed spots at greater depths gave no emergence at all.

The pattern shown in table 3 remained relatively constant well into the period of seedling emergence, but was no longer evident by the time emergence was completed. There was considerable variation between treatments in elapsed time between first and last dates of emergence, but this time variation was not related to depth or seed numbers.

Total Seedling Emergence

Total emergence was unaffected by aspect. Of the 384 spots seeded on each site, seedlings emerged from 134 and 133 spots on the south and west exposures, respectively. Distribution of successful spots (those from which one or more seedlings emerged) among the various depth x number combinations was essentially the same on the two sites, except that there was more emergence from the greater depths on the south exposure than on the west. Spots with 4 or more seeds had emerging seedlings from 2¼ inches on the south-sloping site, while only those

spots with 12 or more seeds had any emergence from that depth on the other site. From the 2-3/4-inch depth the only emergence was on the south exposure, and this from spots with 12, 16, and 24 seeds.

Total emergence resulting from the various depth x number combinations are shown in figure 1. The low emergence at 1/4 inch was caused by loss of seeds; the seeds in approximately one-third of the spots at this depth were heaved out of the ground by frost. The highest emergence rates were, in decreasing order, from the 3/4-, 1¼-, and 1-3/4-inch depths, and the differences between each of these were highly significant ($P < .01$). Seed planted at the 2¼- and 2-3/4-inch depths resulted in a negligible number of successful spots.

The larger seed-group sizes produced more successful spots than the smaller ones. Combined data for all depths, except 1/4 inch, show that the greatest success was obtained from spots seeded to 24 seeds, followed in order by those in which 16, 12, and 8 seeds were planted; each was significantly different from the other ($P < .05$). Spots with 6 and 4 seeds each produced essentially the same results, and these were not significantly different from results obtained with 8 seeds. Spots with 1 and 2 seeds yielded the poorest results.

Seedling Mortality

On each observation date it was noted that some of the seedlings had died since the previous observation. The rate of loss was heaviest the first spring, soon after emergence. Mortality at that time was due largely to moth larvae and damping-off organisms. Subsequent mortality was ascribed mainly to grasshoppers, rodents, and drought. Aspect had a significant effect on mortality, which was 30 percent after two growing seasons on the south exposure and 62 percent on the west exposure; the reason for this difference is not known. Within sites, mortality of seedling groups was not related to depth at which seed was sown, to number of seeds per seed spot, nor to any combination of depth and seed number (figure 2).

The average number of seedlings within successful spots was more or less proportional to the number of seeds that had been planted. Seedlings per group ranged in number from one per spot to as many as twenty. No evidence was found to indicate any relation between original numbers of seedlings within spots and subsequent loss of whole seedling groups; percentagewise, the loss of seedling groups was about the same among those with one or a few seedlings as among those with several.

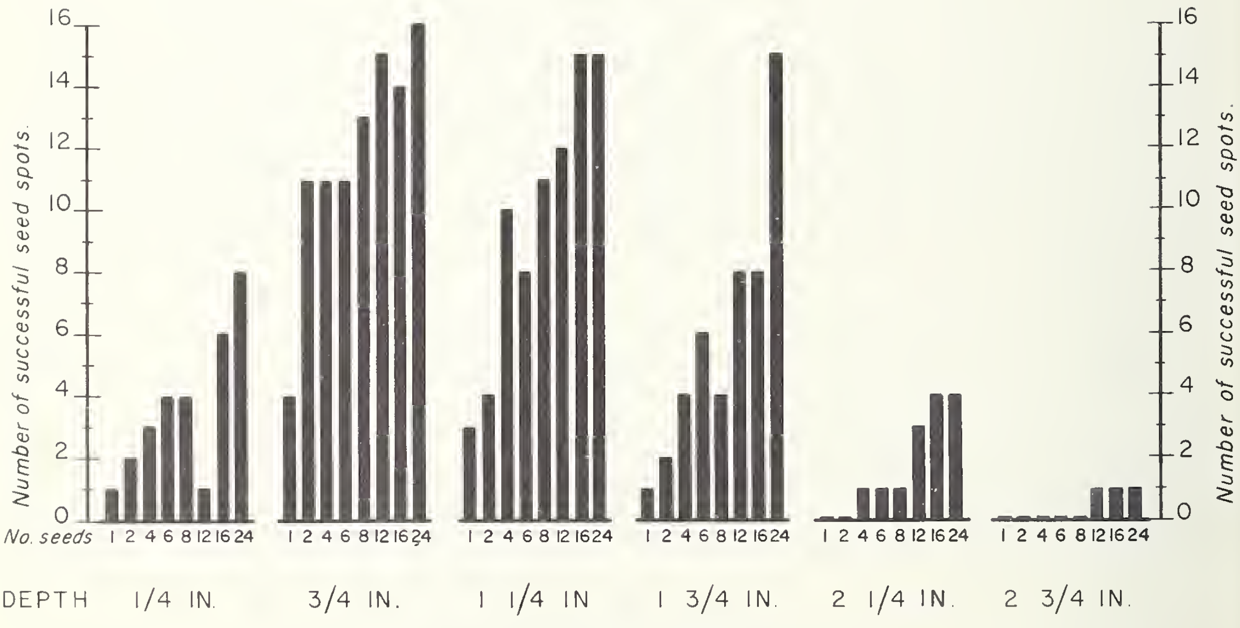

Figure 1.--Number of seed spots with successful emergence of one or more bitterbrush seedlings, spring 1955. Seed spots planted at depths and with number of seeds as indicated in the lower margin. Data from two sites; each combination of depth and number of seeds repeated eight times on each site.

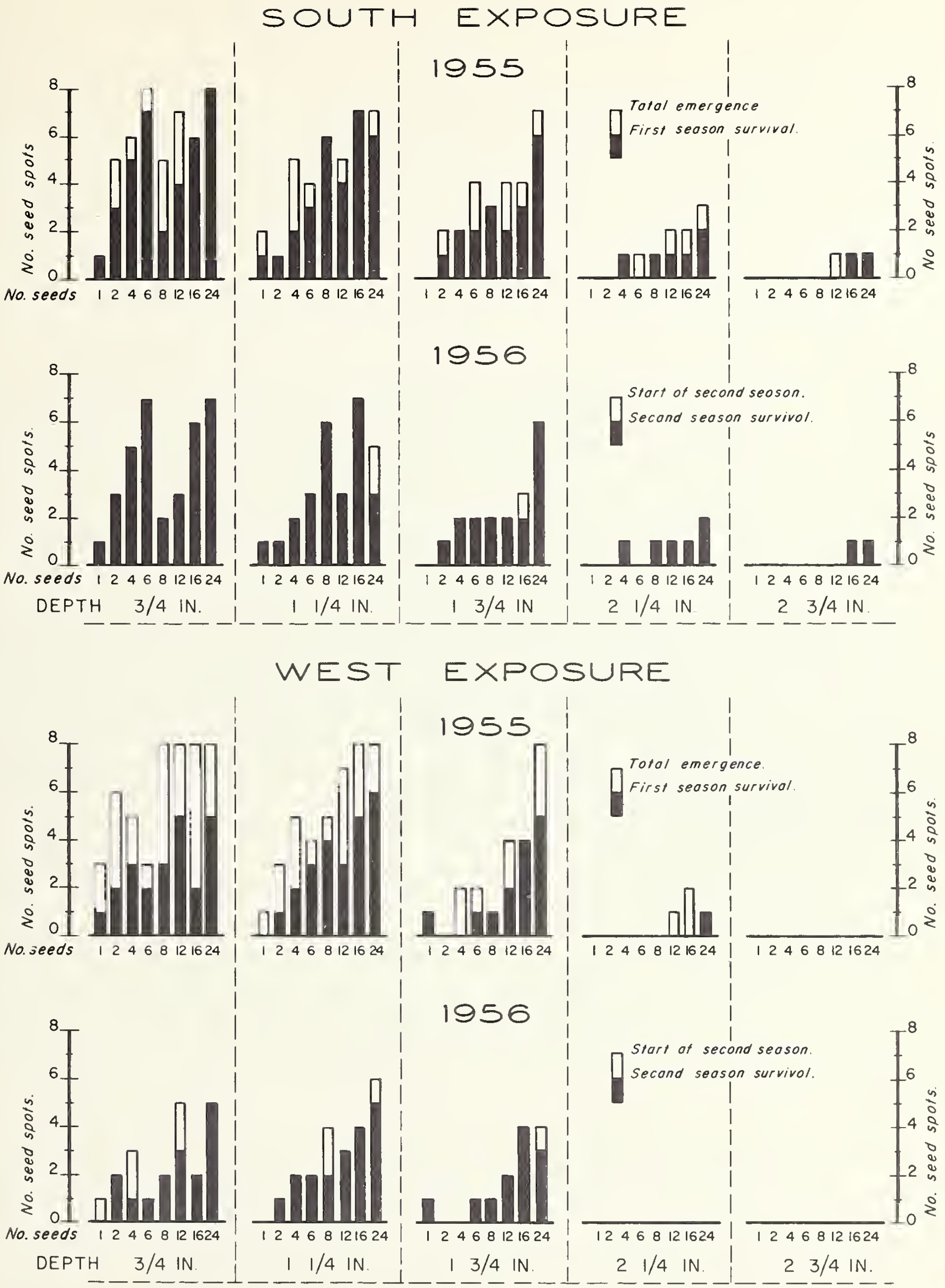

Figure 2.--Seedling survival as shown by number of seed spots with one or more seedlings at beginning and end of first two growing seasons. Each combination of depth seed-group size was replicated eight times on each of two exposures.

SUMMARY AND CONCLUSIONS

Bitterbrush was seeded in the field at two or more depths in five different years. With increasing depth there was increasing delay in date of emergence. This was beneficial in one year, when frost-heaving resulted in loss of some seedlings from 1/4- and 1/2-inch seeding depths, and in three years when many seeds from 1/4 inch were heaved out of the ground before they germinated.

Seedlings from individually placed seeds never emerged from depths of 2 inches or more, although seeds planted singly at 2½ inches appeared on excavation to have germinated.

Where bitterbrush seeds are planted singly, as they are in drill rows, a depth of 1/2 inch probably is optimum for best emergence in the coarse sandy loams of certain southwestern Idaho game winter ranges. In some years frost damage may cause partial loss to seedlings coming from this depth, but the delay in emergence and the resultant protection from frost that can be obtained by seeding at greater depths will probably no more than compensate for the reduction in number of emerged seedlings that accompanies an increase in depth.

Where steep slopes necessitate spot seeding, a seeding depth of 3/4 inch is recommended. From this depth, in three separate years, no seed spots or seedlings were ever damaged by frost. A reduction in number of successfully emerging spots can be expected from this depth, as compared with 1/2 inch, but this can be overcome by increasing the number of seeds per spot. The extra seed is additional seeding expense, but seed costs little compared with labor. Increasing the number of seeds per spot would enhance the success and thereby strengthen the economic feasibility of a revegetation project.

For spot seedings, the most economical way to get seedlings well distributed over the area would appear to be by seeding on small, prepared seedbeds (i.e. scalped areas about 2 feet across) separated from each other by the distance that mature shrubs of the desired stand density would be. Each scalp would contain three seed spots a few inches apart, and each spot would contain 6 to 8 seeds at a depth of 3/4 inch. A larger number of seeds per spot would increase emergence, but the accompanying advancement in date of emergence might result in some seedling mortality from frost.

Of course, even with the best emergence considerable mortality can be expected, since seedlings are subject to many adverse factors during their first growing season. Neither seedling mortality nor failure of seed spots after emergence appears to be related to numbers of seed planted, depth of seeding (if deep enough to prevent frost damage), or numbers of seedlings growing together in the same seed spot. Similar studies were reported by Hubbard,[2/] who, in six bitterbrush seeding trials in California, did not find seedling survival to be related to planting depth. It follows, then, that while careful depth control is necessary for maximum emergence, other means of increasing survival must be sought in southwestern Idaho.

[2/] Hubbard, Richard L. 1956. Effect of depth of planting on the emergence of bitterbrush seedlings. Calif. Forest and Range Expt. Sta. Research Note 113.